111A

Application Based on U.S. Provisional Application Serial No. 60/236,443 filed October 2, 2000

Docket **82596DAN**
Inventors: Ray Hicks
Customer No. 01333

ARTICULATING CAMERA FOR DIGITAL IMAGE ACQUISITION

Commissioner for Patents,
ATTN: BOX PATENT APPLICATION
Washington, D. C. 20231

Express Mail Label No.: EL656967238US

Date: September 21, 2001

G:\Mss\DAN\DOCKETS\82596\A\exppage.doc
21 September 2001 08:35 AM

ARTICULATING CAMERA FOR DIGITAL IMAGE ACQUISITION

RELATED APPLICATION

This application is related to, and claims the benefit of priority from, United States Provisional Patent Application Serial No. 60/236,443, filed October 2, 2000.

FIELD OF THE INVENTION

The invention pertains to an apparatus for capturing a digital image from a photographic negative, and more specifically, for selectively positioning a photographic image capturing device in relation to a continuous roll of photographic negatives.

BACKGROUND OF THE INVENTION

Conventional chemical photographic image processing has evolved from manual to semi-automatic to nearly fully automatic operation in recent years. Additionally, the wide availability of high quality digital photographic image processing equipment has further streamlined the process of editing photographic images and producing prints from negatives. These advances have resulted in substantially reduced costs, as well.

In the traditional photographic image processing operations prevalent at high volume photographic laboratories, it is known to splice several rolls of developed film together to form a continuous strip of photographic negatives, each strip containing several hundred individual images. To keep track of these images and edit them in a high production environment is a complex task. Each photographic image must be identified by a discrete code or number. This code may then be correlated with identifying data regarding the image, for example, the name and address of the photographer, the photographer's job number, the frame number within the photographer's job, as well as color correction, balance, cropping and orientation information. Only by associating all of this information with a discrete identifying number can the photographic laboratory and its

customer, the photographer, be assured that photographic prints generated from the photographic negatives are correctly produced and routed.

It is well known to produce photographic film processing machines which automatically detect the edge of individual photographic frames on a long roll of developed photographic negative film, and to affix to each frame (usually at the edge) a marking, often in the form of punched holes or notches to identify each frame. It is also well known to use such marked film in a photographic editing and/or printing apparatus, and to manipulate the film in relation to a fixed photographic imaging apparatus such as an enlarger or lamp house, or in relation to a digital video imaging device such as a CCD digital video camera.

Traditionally, such video imaging devices have been fixed in relation to the path of travel of the long roll of negatives being imaged, and correction of tilted images, reorientation between landscape and portrait formats, and selection of optical centers of the image have been handled by selective movement of a carrier upon which the strip of negative film is mounted. Examples of this type of technology can be found in my U.S. Patent No. 5,097,292. The focus of the video imaging device in relation to the negative images on the film has also been fixed, preventing corrections for out-of-focus conditions which may arise.

It is equally well known to utilize digital cameras to transfer photographic images, in digital format, to computers or to computer databases. A simple example of this type of device is found in U.S. Patent No. 5,920,342 (Umeda). The video-imaging devices taught in the prior art, however, are incapable of providing customized articulated movement in relationship to the plane of the image being scanned.

SUMMARY OF THE INVENTION

My invention incorporates the use of an articulating digital photographic imaging device associated with a long roll film transport, edge detector and punch.

It is possible to enhance the productivity of the photographic laboratory by further automating the long roll film handling process utilizing my invention. The

image capture and encoding device herein described detects frame numbers, punches frame numbers and acquires high quality full frame digital images from a wide variety of film formats. Utilizing an articulating camera assembly, formatting, editing and image size variations can be done through software control by virtue of appropriate electrical connections and instructions between the image capture and encoding device and a digital computer. The device combines several process steps, previously performed in discrete locations, into a single work station.

The frame edge detection element automatically detects frame edges and so identifies the optical center of each individual frame. The hole punch element places standard binary punch patterns on each individual frame in one embodiment.

A digital CCD camera, associated with a tri-color (RGB) light source is mounted to provide camera movement in relation to the film. Using appropriate digitally controlled motors,, the distance of the camera from the film, the Y-axis positioning of the camera in relationship to the film center line, the rotation of the camera and focusing can all be controlled utilizing an associated computer running a conventional operating system and specialized software which forms a part of my invention.

Embodiments of my invention include the ability to separately identify frames from appropriately perforated film, and to read bar codes encoded on the film. The associated software provided with my invention permits a full range of editing, including photograph composition, color balance, orientation, enlargement, refocusing, tilting and touch-up. By providing both the laboratory and the photographer with complimentary software, editing and printing instructions may be freely exchanged utilizing transportable media or computer networks to transmit data between the photographer, the photographic laboratory and the customer.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of the image capture and encoding portion of the apparatus, showing its interconnection to a computer and data network.

______Figure 2 is a flow chart outlining the initial image capture steps.

Figure 3 is a flow chart showing secondary editing steps.

Figure 4 is an exploded view of the main structural elements of the image capture and encoding station.

Figure 5 is an exploded view showing the placement of the major components of the image capture and encoding station.

Figure 6 is an exploded view of the digital camera in relation to the major components of the Z-axis transport.

Figure 7 is an exploded view showing the digital camera in relation to the major components of the Y-axis transport.

Figure 8 is an exploded view showing the digital camera in relation to the rotational position and focus function of the camera.

Figures 9A-9D are an exploded views of the main components of the lamp house.

Figure 10 is an exploded view showing the main housing components of the image capture and encoding station.

Figure 11 is a front view of a portion of the image capture and encoding station showing the routing of the film.

Figure 12 is a view of the major pneumatic and vacuum components and their interconnection, and

Figure 12A is a view of the major pneumatic and vacuum components shown in relation to the main structural components of the image capture and encoding status.

DETAILED DESCRIPTION OF THE INVENTION

The operation of the invention will best be understood first by reference to the overall process defining the environment in which the hardware and software perform, next by analyzing the overall configuration and interconnection of the

various hardware elements, and finally by analyzing the hardware elements of the invention in detail.

Figure 2 and Figure 3 are simplified flow charts of operations. The image capture and encoding apparatus 10 (as shown in Figure 1) is designed to operate on a long roll of film, typically created from splicing together two or more rolls of film exposed by the photographer during a typical photographic job. In some instances, the long roll of film may contain multiple jobs for the same photographer, and on rare occasions, may include multiple rolls of film from multiple photographers. The rolls of film are spliced together using well known techniques, thereby presenting to the image capture and encoding apparatus **10** a continuous strip of film, often including several hundred individual exposures.

The next step in the film image capture process is the accurate detection of a leading or trailing edge of the individual frames found on the film. Typically, this involves the use of an array of optical sensors positioned in relation to the film, and comparing detailed information regarding the optical density of the film in relation to known standards. These techniques, which are well known, result in the reliable detection of at least one edge of the exposure constituting what is conventionally viewed as a negative image on developed photographic film.

Once the edge of the image is detected, a suitable apparatus, having been provided with information regarding the precise dimensions of each exposure on the film, is able to position each successive photographic image, properly centered, in proximity to an image capturing device, such as a solid state video camera. Simultaneously with the positioning of the film, the film is illuminated, usually from the side opposite the video camera, to project the negative image to the video camera. This procedure, which will be explained further on in this disclosure, results in the creation of one or more digitized images corresponding to the negative image. This digital information is stored in a pre-established format for later use.

Simultaneously with capture of image, the edge of the film is punched

proximate to each negative image. As a result, each frame of the photographic film is provided with a permanent identifying mark near the film edge, where it does not interfere with the appearance of the photographic image, either when digitized, or when printed to photographic paper.

The next step in the process is the creation of a data base of digital images, which are organized and stored into a digital file for transmission to the photographer and/or the photographer's customer. Typically, at this point in time, the images are "proof" images only, having merely been scanned, captured and identified by an appropriate code, subjected to preliminary editing and placed into an appropriate digital file. The preliminary editing is accomplished using image inspection software, and may include color correction, positioning and orientation edits, for example.

The purpose of all of the foregoing steps is to create for the photographic laboratory and for the originating photographer a collection of digital proofs which can be viewed and edited further. These digital proofs may be transmitted by the laboratory to the photographer utilizing an inexpensive transportable medium, such as CD ROM, or may be transmitted to the photographer and/or his or her customer by transmitting the data over a network, such as the Internet. Once the photographer either independently, or with input from the customer, has viewed the proofs, the photographer will typically select one or more of the images for final production. The photographer will specify for the laboratory a variety of parameters for each image to be produced as a finished print. Sample parameters are image orientation (e.g. landscape or portrait), color balance, centering and cropping, magnification, print size, or color correction. Further, the photographer may provide to the laboratory instructions for retouching of photographs to remove blemishes, alter skin tone, remove undesirable reflections or add graphics or matting.

Once these editing decisions have been made, the process continues as outlined in the flow chart shown in Figure 3. The database of editing information

provided by the photographer, and corresponding to the database of images produced in the initial imaging steps provides the photograph laboratory useful editing information in relation to the previously presented roll of film. Once this information has been received, the previously scanned and punched film is again loaded to the image capture and encoding apparatus, mounted and threaded for further processing. At this stage of the process, each image selected by the photographer for printing is identified by its edge code and transported by the apparatus to its optical stage. Utilizing the editing information provided by the photographer, the magnification, focus, orientation, tilt, cropping, and color balance of the image may be adjusted as the image is recaptured for production purposes.

The photographic image may then be produced directly by digital output from the edited digital image, or the revised editing information created during the recapture process may be utilized to drive the components of a conventional photograph printer to insure correct orientation, cropping, color balance, and other parameters when the photographic image is presented to the photographic printer for the exposure of photographic paper.

In Figure 1, the major components of the image capture and encoding apparatus are depicted. The principal components are the film encoding station **12**, the computer **14**, the computer keyboard **16**, the computer monitor **18** and the secondary computer input device **20**, in one embodiment, a mouse, although a track ball or digital writing tablet performs equally well. The film encoding station **12**, and its associated internal electronic components, are connected by cable **22** or infrared data ports to the computer **14**. The computer **14**, in turn, may be appropriately connected to a computer network **24** utilizing well known data processing network equipment and techniques.

The computer **14**, keyboard **16**, and input device **20** are preferably stand alone desktop type personal computer components of the type manufactured by IBM®, Hewlett Packard®, Dell®, Compak®, and a wide variety of other

manufacturers. Typically, these computers are provided with a central processing unit, random access memory of sufficient size to accommodate the relatively large file sizes resulting from the capture of digital images, one or more storage devices, such as hard disk drives, capable of storing a large number of the relatively large files previously discussed, and frequently, a disk drive capable of both reading and writing to large capacity removable storage mediums, such as the commercially available Zip® drive, rewritable CD ROMs or removable hard disks. The computer monitor **18** is typically selected from that group of color computer monitors capable of generating a wide range of color information, and producing accurate representations of photographic images in a variety of formats, such as RGB, CMYK and grey scale formats. The computer **14** and its associated components serve as the interface between the film encoding station **12** and the operator, and further serve to depict both edited and unedited images, image collections, and data associated with each image. The computer **14** further serves as the portal by which photographic image data may be transmitted over a network **24**, or to other output devices.

The film encoding station **12** comprises a base plate **36**, a front tool plate **38**, a rear tool plate **40** (not shown in this view), a housing assembly **28** and a front cover **33**, all of which serve to support and enclose the major operating components of the film encoding station **12**. Affixed to the base plate **36** and tool plates **38** and **40** are an articulating camera **15**, a feed spool **80**, a take-up spool **82**, a feed roller array **84**, a take-up roller array **86**, a drive roller **88**, a sensor **90**, a film punch assembly **92** and a lamp house assembly **94**. Contained within the interior of the housing **28** are the various electrical, pneumatic and mechanical components which drive and control the operation of the film encoding station **12**.

Further detail of the major components of the film encoding station can be best appreciated by reference to Figure 4. The structural and operative elements of the film encoding station **12** are mounted to a framework providing a secure platform for the mounting of the various components. It is important to recognize

that the film optical stage and camera must be rigidly mounted to extremely fine tolerances to insure both a high degree of repeatability and a high degree of precision in photographic imaging. The various elements of the film encoding station framework are enclosed by a housing assembly **28**, consisting of housing side elements **30** and **32**, base plate **36**, front tool plate **38** and rear tool plate **40**. The housing elements, when assembled, serve to enclose and protect the most sensitive components of the station, to support the various operative components and to further protect the operator from the hazards associated with moving components and high voltage electricity in this type of equipment. A plurality of foot elements **41** supports the base plate 36 from beneath.

Front tool plate **38** and rear tool plate **40** provide the support for the various spool shafts, roller shafts, and Y, Z-axis travel block, motors, punch assembly, edge detecting assembly, light source assembly, film hold down assembly, and punch waste receptacle. The tool plates **38** and **40** further provide support for the Y-axis mounting spacer **220** and a cropping template mounting block **221**. Cooling exhaust fans are mounted to the housing to ventilate the interior of the housing.

Figure 4 further shows the tool plates in relation to the lamp house top **54** and sides **59** and **56**. An LED circuit board bracket **61** provides support for the primary light source LEDs. In the preferred embodiment, front tool plate **38**, rear tool plate **40**, housing sides **30** and **32**, base plate **36**, and lamp house elements are fastened together using traditional fastening means such as screws **100**, to create the necessary physical support for the attached components. Front tool plate **38** and rear tool plate **40** are further interconnected by the screws **100**, and separated by standoffs **52**. Together these elements form the necessary physical structure of the device, to support the camera, film drive and lamp house.

As seen in more detail in Figure 5, front tool plate **38** and rear tool plate **40**, when fastened together, form an assembly which supports, in part, the lamp house top **54**, lamp house left side **59** and lamp house right side **56**. The perimeter

of front tool plate **38** also provides the mounting support surface for the perimeter of housing right side **32** and housing left side **30**. Front and rear tool plates **38** and **40** further provide support for feed spool shaft **81**. The feed spool shaft **81** is driven by an intelligent tensioning motor **102**, which is coupled to feed spool shaft **81** by a coupling **104**. The intelligent tensioning motor **102** is mounted to the rear tool plate **40** by spacers **106**, washers **101** and fasteners **100**. Feed spool shaft **81** is further supported by bearings **108**, which provide a low friction fitting for the rotation of the feed spool shaft **81** in relation to front tool plate **38** and rear tool plate **40**. The feed spool shaft **81** is further provided with a collar **111**, washers **101**, a spacer **110** and locking flange **112**, which together serve to position and secure the film feed spool. Adjoining the feed spool shaft **81** is an idler roller **116** supported by an idler roller shaft **118**, which is supported on the front tool plate **38** and rear tool plate **40** by bearings **108** and snap ring **114**. Adjacent the idler roller are one or more particle transfer rollers **120** mounted on particle transfer roller shafts **122** utilizing bearings **108**. Particle transfer rollers **120** are surfaced with a low tack adhesive to cause dust and other particles on the film to adhere to the surface of the particle transfer roller **120**. Particle transfer rollers **120** are designed to be cleanable and reusable after becoming contaminated or soiled. Particle transfer rollers **120** are affixed to the front tool plate **38** and rear tool plate **40** utilizing conventional fasteners **100**, washers **101**, and snap ring **114**. Adjacent to the particle transfer rollers **120** is a feed guide roller **124** which is pivotally mounted to guide roller shaft **126**. Guide roller shaft **126** is mounted to front tool plate **38** and rear tool plate **40** utilizing one or more bearings **108** and snap rings **114**. Guide roller **124** is incrementally adjustable to establish a width between guide portions **125** of guide roller **124** to accommodate varying widths of film. Tension on the film is maintained by a film tensioning roller **130**, mounted on bearings **108**, which are, in turn, mounted on the tensioning roller shaft **132**. The tensioning roller shaft **132** is mounted to a distal end of bail arm **134**. The proximal end **136** of the bail arm **134** is mounted to the bail arm pivot shaft **138**,

which, in turn, is mounted on bearings **108** fixed to front tool plate **38** and rear tool plate **40**. Bail arm pivot shaft **138** protrudes through the rear tool plate **40** where it is provided with a spring **190**, retaining collar **140**, a switch vane collar **142** and a second retaining collar **144**. Switch vane collar **142** provides positioning information to the intelligent tensioning motor **102** to insure that the appropriate tension is maintained on the film moving through the system.

The principal film optical stage is the lamp house top **54**; the film is conveyed across the lamp house top **54** during the sensing, imaging and punching operations. The various guide and tensioning rollers herein described serve to position the longitudinal or X-axis of the film in relation to a camera **15** which is mounted, as will be explained in detail herein, in relation to the front tool plate **38** and lamp house top **54** to insure exposure of the film. The film is illuminated from below by a lamp house mixer **50** fixed to a lamp house mounting bracket **51**, which, in turn, is mounted to the front tool plate **38** using fasteners **100**. The lamp house mounting bracket also provides support for power resistors **150**, attached to a lamp house mount bracket **51** which also acts as a heat sink for the resistors **150**.

After passing over the lamp house top **54**, the film is fed over guide rollers **160**, which are mounted on guide roller shafts **162**, which in turn are secured to the front tool plate **38** and rear tool plate **40** utilizing bearings **108** and snap rings **114**. Between guide rollers **160** and **164** is the primary drive roller **170**, which is affixed to drive roller shaft **172**. Drive roller shaft **172** is mounted on bearings **108** and protrudes through to the rear side of the rear tool plate **40** where it is provided with a drive pulley **174** which provides the necessary film advance. The film is then routed over appropriate idler rollers **176** mounted to idler roller shafts **178**, which, are in turn, mounted to the front tool plate **38** and rear tool plate **40** by bearings **108** and snap ring **114**. The film is then routed over a take-up tensioning roller **180** which is mounted by bearings **108** to tensioning roller shaft **182** attached to the distal end of bail arm **184**. The proximal end **183** of bail arm

184 is affixed to bail arm pivot shaft **186** which is in turn mounted on bearings **108** and to front tool plate **38** and rear tool plate **40**. Bail arm pivot shaft **186** is provided with a tensioning spring **190**, a collar **140**, a switch vane collar **142** and a second retaining collar **144**. In a fashion identical to the counterpart tensioning roller on the feed side of the invention, the switch vane collar **142** provides a positioning signal to the electronic circuitry of the system to maintain appropriate tension on the film. A take-up spool is mounted on a take-up spool shaft **202** which is mounted on bearings **108** to the front tool plate **38** and rear tool plate **40**. The take-up spool is positioned on shaft **202** by spacer **110** and locking flange **112**. One end of take-up spool shaft **202** is mounted via a coupling **204** to an intelligent tensioning motor **206** which is mounted to the rear tool plate by appropriate standoffs **110** and fasteners **100**.

At least one side of the housing, and as shown in the embodiment pictured in Figure 5, the housing left side contains a cooling fan **42** which is provided with both a fan guard **43** and a cover **44**. Affixed to the front tool plate **38** is a punch receptacle **210** for receiving the waste punch material generated by the film punch (not shown). The punch receptacle **210** is attached to the front tool plate **38** by a punch receptacle bracket **212** and suitable fasteners **100**. The punch receptacle **210** is provided with an inlet **214** and an outlet **216**, to provide a pathway for sucking the punch waste into the receptacle as well as for connection to a vacuum source.

Reference to Figures 6-8 will facilitate an understanding of the operation of the video imaging camera assembly. The video imaging camera **15** is provided with a variable focus lens **58**, which is a multi element lens of desired optical characteristics complimentary to the video camera and to the resolution of a wide range of color images. Camera **15** is secured to y-axis travel block **220** via camera ring **222**. Travel block **220** is also attached to lens ring **224** using suitable fasteners **100**. Y-axis travel block **220** is, in turn, provided with camera rotating ring **226**. Rotator ring **226** is preferably in the form of a bearing or bushing

thereby permitting camera to rotate freely within the Y-axis travel block **220**. Motor **229** drives rotation pulley **223** and belt **233** to effect rotation of camera **15** in rotation to Y-axis block **220**. Sensor flag **237** provides camera rotational signals to sensors **235**. The camera is further secured to the Y-axis travel block **220** by camera retainer ring **228**, utilizing fasteners. The Y-axis travel block **220** is mounted to a pair of Y-axis travel shafts **230** via through bores **232** in travel block. Low friction bushings **234** are press-fit into the bores **232** of travel block **220** and provided with retainers **239** to provide a low friction slidable relationship between travel shafts **230** and travel block **220**. Lens **58** is provided with a pulley adapter **236**, adapted to be engaged with a pulley belt **238**. Y-axis movement of the travel block is imparted by means of a linear actuator **240**. Selective positioning of the Y-axis travel block **220** is achieved by transmission of an appropriate signal which corresponds to a precise position of the linear actuator **240**, and accordingly, a precise position of the Y-axis travel block **220** in relation to the optical stage of the apparatus. With continuing reference to Figure 6, it can be seen that Z-axis travel block **244** accepts one end of Y-axis travel shafts **230**. Z-axis travel block **244** is, in turn, provided with through bores **246** which accept Z-axis travel shafts **248** and Z-axis lead screw **250**, with a provision for bearings **252** and retainers **239** which provide a relatively frictionless surface surrounding Z-axis travel shafts **248**, permitting smooth vertical movement of the Z-axis travel block and the components mounted thereto. The upper and lower ends of the Z-axis travel shafts **248** and Z-axis lead screw **250** are affixed utilizing bearings **108** to upper shaft block **260** and lower shaft block **262** which, in turn, are affixed to the rear tool plate. A floating nut assembly **264** is placed in cavity **266** of Z-axis travel block, thereby engaging the threads of Z-axis lead screw **250**. Rotation of Z-axis lead screw **250** drives Z-axis travel block **244** upwards and downwards, thereby repositioning camera **15** in relation to the plane of the film mounted on the image capture and encoding apparatus. The upper end of lead screw **250** passes through a bearing **268** in upper shaft block, and thence engages a flex coupling **270** and a

stepper motor **272.** The stopper motor **272** is mounted with standoffs **247** and fasteners **100**, and drives rotation of lead screw **250**. Sensor flags **241** provide reference position for sensors (not shown) to provide position information for the travel blocks.

Lens **58** has affixed thereto a lens focus motor mount **280**. Attached to lens focus motor mount **280** is the lens focus drive motor **281,** focus motor mount plate 283 and standoffs **285,** all held together by conventional fasteners **100** with associated nuts, lock washers and washers. Affixed to lens assembly **58** is lens pulley adapter **236**, to which is affixed lens focus sensor flag **287**. Lens pulley drive **284** drives lens pulley **238,** and in turn, lens pulley adapter **236** to alter the lens focus. The lens **58** is appropriately spaced from camera **15** by spacers **282**. Sensor **286** is mounted to spacer block **288** by conventional fasteners.

It can be seen from this description that the various components described, including the travel blocks, shafts, lens, and rotating rings, result in an articulated camera assembly which may be urged to move vertically (the Z-axis) horizontally (the Y-axis), rotated (the R-axis), and vary in focus in relation to the plane of a negative being transported in the apparatus. Movements in each of these axes may be under computer control, or may be manual, depending on the operator's preference.

The structure and function of the lamp house may be seen by reference to Figs. 9A-9D. The lamp house consists of a top **54**, a right side **56**, and a left side **59**. Affixed to a top plate **54** are a negative glass **48** and a diffuser glass **49**, a film guide assembly **57** is affixed to top **54** plate by suitable fasteners. Anti curl rollers are affixed to film guide assembly **57** to stabilize the film edges as the film is transported across the lamp house top **54**. A LED light source printed circuit board **62** is mounted directly beneath the mixing chamber (not shown) by guides **73** affixed to bracket **61**. The LED light source printed circuit board **62** is comprised of red, green and blue light emitting diodes, each group (R, G & B) is individually computer-controlled for precise exposure time. Each LED group is

selectively operable allowing all, or any portion, of the array of light emitting diodes to be operated as desired.

To assist in the dissipation of the heat generated within the lamp house, the lamp house is provided with a lamp house fan **14**, which is affixed by fasteners **100** to the lamp house right side **56**, and provided with a lamp house guard **66**, a filter **68** and a fan cover **70**.

Because the apparatus relies upon a pneumatic power source to hold down the film and to operate the punch, a pneumatic source and distribution system is required, as shown in Figure 12. The vacuum sources may be a venturi vacuum pump **200**, which is selectively activated. A high pressure air inlet **302** is mounted to either the housing **28** or base plate **36** so as to be physically secure. Typically, the air inlet is provided with a quick disconnect nipple **301** which allows for easy connection and disconnection of a source of high pressure air. The inner inlet is connected by appropriate pneumatic tubing **303** to an on-off valve **304** which opens and closes in response to the application or removal of main system power to the station. The valve routes high pressure air to an air regulator **306** which is provided with an outlet pressure indicator **308**, as well as a regulator to provide a known pressure of high pressure air to the remaining components of the pneumatic system. The regulator high pressure air is then routed to a T **310** which provides regulated high pressure air to the valve stack **312** as well as to the pneumatic manifold **314**.

A further understanding of the system will be best understood by first understanding the vacuum system, comprising the vacuum pump **200**, the vacuum controller **316** and the associated tubing **318**. The vacuum pump provides a source of vacuum to the punch receptacle **210**. Coupled with pressure from the manifold **314** provided to the punch assembly **332** through punch waste pressure line **320**, punch waste is routed through the punch waste discharge tubing **322** to the punch receptacle **210**.

Turning now to the pressure side of the pneumatic system, it can be seen

that high pressure air is routed to valve stack **312**, consisting of ten pneumatic valves. The position of each of the ten pneumatic valves is determined by electrical signals from the computer **14**. The outlet **313** of each of the valves in the ten valve stack is connected by tubing arrays **330** to the punch assembly **332**, thereby positioning the individual punches of the punch assembly **332** in a predetermined order. Typically, this punch system order is a binary code of ten bits, allowing encoding of numbers up to 2^{10}. Once the valve stack **312** has sent the appropriate pneumatic signals to the editor punch assembly **332**, an appropriate signal is sent to the editor punch assembly valve **334** to provide punching pneumatic pressure to the editor punch assembly **332**, thereby driving the selected punch elements of the punch assembly **332** through the edge of the film. The pneumatic manifold **314** also provides a selective signal to the film hold-down cylinder **340**, to operate the necessary film hold-down elements (not shown) to hold the film against the lamp house top **54** and negative glass **48** during image capture and encoding. The front tool plate **38** and rear tool plate **40** and base plate **36** are shown in ghost view in relation to the main pneumatic components in Figure 12A. In one embodiment of the invention, the valve stack **312** is secured to the rear tool plate **40**. The pneumatic manifold **314** is preferably mounted to the base plate **36**. Air inlet **302**, valve **304** and a regulator **306** may be mounted in any location within the housing **28**, but are typically affixed to rear cover **34**. Vacuum pump **200** may likewise be mounted anywhere within the housing **78**, and in one embodiment is affixed to the interior side of the front tool plate **38**. Punch assembly **332** is secured to front tool plate **38**. Punch receptacle **210** is mounted to the front or exterior side of front tool plate **38** where it is easily accessible to the operator for emptying.

Activation of the punch assembly **332** mechanism itself forces individual punch elements to and through the film surface. As the punch system is actuated, a vacuum is applied to the punch chip reservoir **210**, which is mounted to be easily removed from the apparatus so that it can be emptied and reattached. The vacuum

facilitates separation of the chips punched from the film, urging them into the reservoir **210**.

With reference to Figures 10 and 11, detailed operation of the complete system proceeds as follows: A long roll of film **13** is mounted to feed spool **80**. The free end of the film is routed around idler roller **116**, tensioning roller **130**, particle transfer rollers **120**, guide roller **124** and across the optical stage of the lamp house **50**. The film **13** is then fed across guide rollers **160**, drive roller **174**, particle transfer rollers **120**, and tensioning roller **180** to a take-up spool **82** mounted on take-up spool shaft **83**. The film feed shaft **81** and film take-up spool shaft **83** are driven, respectively, by film drive motors and film take-up spool motors (not shown), which serve to position the longitudinal or X-axis of the film in a desired position in relation to camera **15** and lamp house **50**. Utilizing selective film drive techniques which are well known, the X-axis or position of the longitudinal centerline of the film can be precisely located in relation to the optical center of the lens **58** associated with camera **15**. One edge of the film is positioned in relation to a film punch **332** located proximate the discharge end of the lamp house **50**. A film chip reservoir **210** is provided to receive film chips generated by the film punch. During initial processing of the film long roll, the edge of each frame of the film is detected by edge sensor **90**, and thereafter provided with a discrete punch code by punch **332**. This discrete punch code serves to corelate and identify each frame of the long roll of film and associated digital data created and stored during the editing processes.

To facilitate servicing of the various components, certain elements of the housing are readily removable. Rear cover **34** is provided with a plurality of quarter turn fasteners **400**, which, in turn, are provided with spring elements **402**, washers **404** and split rings **408** designed to secure the quarter turn fasteners within holes **406** around the perimeter of the rear cover **34**. The quarter turn fasteners **400** are likewise positioned to engage holes **409** and quarter turn fastener retainers **410** which are affixed to the perimeter of housing sides **30** and **32**.

Preferably, the quarter turn fastener retainers **410** are affixed to the perimeter of the housing sides by rivets **412**. In this fashion, the rear cover can be removed from the station quickly without the need for sophisticated tools. The rear cover **34** is also provided with a top shroud **35** which, in one embodiment, is also provided with a cooling fan **402**, a cooling fan guard **43**, air filter **68** and cooling fan cover **44**. The lamp house **50** portion of the station is likewise provided with a front cover **53** provided with operating switches **418** for providing both electric and pneumatic power to the device. It is typical to provide an identification plate **420** affixed to the front of the lamp house cover **53** to provide the manufacturer's name, as well as the model name, operating voltages, and other specifications for the system.

As each frame of the film long roll is detected and punched, it is simultaneously presented to the lamp house **50** stage. The lamp house is then illuminated, thereby presenting an image to camera **15**. The image so presented is simultaneously displayed on computer monitor **18** as depicted in Figure 1. Utilizing the visual image provided by computer monitor **18**, the operator can provide multiple editing and positioning information. Specifically, the operator can view the image for color balance, common defects such as retinal reflection ("red eye"), closed eyes ("blink"), poor color balance, skin blemishes and other fundamental defects affecting the appearance of the photographic subject. At the same time, the operator can position the camera **15** in both the Y and Z axis and can rotate the camera about its central optical axis, the "R" axis, as well as apply cropping information. This permits a preliminarily edited image to be created in either landscape or portrait format or selectively rotated to a format intermediate landscape and portrait for artistic purposes.

Once the image has been evaluated and preliminarily edited as above-described, the image, together with its identifying code, camera position and associated preliminary edits is stored as a digital image. The finished image may be stored as a raw image and the editing information stored separately, or the

image may be fully edited and only the edited image stored. The operator continues the editing process throughout each desired image of the long roll of film. Each image with its associated editing information is stored in a data base, wherein each data base record is discretely identified by the film frame code. Utilizing this code, therefore, the data for each individual image is easily retrieved.

Operation of the invention continues with transmission of the image and editing data to the originating photographer. Typically, this transmission takes place over a wide area network such as the internet, enabling the originating photographer to view the preliminarily edited photographs without the need for generating printed proofs. The originating photographer can easily review the photographs in the company of the ultimate customer, or can transmit the digital images to the ultimate customer for comment and ordering. After the originating photographer reviews the images and obtains an order from the customer, the originating photographer will transmit additional editing information to the photographic laboratory, together with ordering information.

At this stage, the output process begins. The original long roll film is again loaded into the image capture and encoding station which is, as previously discussed, provided with the necessary edge detection and punch code reader hardware insuring that the registration of the film during the original editing process can be precisely duplicated during the output process. Punch assembly **332** incorporates a punch code reader which permits identification of each frame. As each frame is detected and identified, therefore, the film positioning information from the original editing process is used to re-register the film **13** and camera **15** in the precise position established during the original editing step. Each frame is identified as one which will or will not be printed, as an initial step. Those frames which will not be printed are bypassed, and only those frames which will be printed are the subject of further processing. As each frame to be printed is presented to the optical stage of the image capture and encoding station, the original editing information provided in the original editing step, together with the

editing data provided by the originating photographer are retrieved by the computer and applied to the image capture and encoding station, thereby simultaneously positioning the camera in Y and R axis as well as focus. Appropriate cropping and color balance information, as well as detailed edits of the photographic image are applied. With each of the above parameters thereby established and applied, the final image is then captured and output, either directly to digital output, or the parameters may be utilized to drive a conventional photographic printer, thereby regulating image size, cropping, color balance, masking, matting and orientation. Having thus described my invention, numerous insubstantial variations will be obvious to those skilled in the art, without departing from the invention, which I claim as follows: